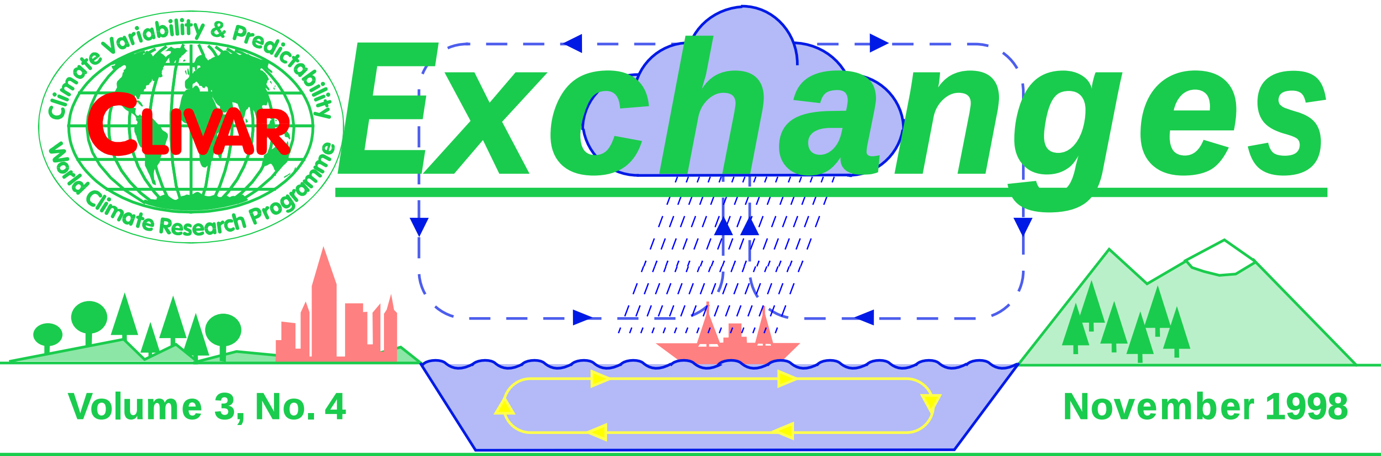
Newsletter of the Climate Variability and Predictability Programme (CLIVAR)

Exchanges



Volume 3, No. 4

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In this issue:

A milestone in CLIVAR development

The International CLIVAR Conference

As I write this piece for CLIVAR Exchanges the ICPO staff in Southampton and Hamburg are busily making preparations for the CLIVAR Conference that is now only a few weeks away. Trying to keep the diverse community of CLIVAR scientists up to date with the evolving Conference plans has been difficult but what we do seem to have succeeded in doing is stimulating countries to start to formulate their national plans. Our present estimates show that we will have around 50 countries represented, spanning all the continents and encompassing some countries that will bring to bear large research resources and many more that will ultimately benefit from CLIVAR research. The first national CLIVAR planning documents are ready. It promises to be a stimulating meeting and one that will set the scene for the first phase of CLIVAR implementation.

The Conference will follow closely after the 4th meeting of the Conference of the Parties in Buenos Aires and the issues discussed there and in meetings in the run-up to the next IPCC assessment will highlight the immediate relevance of CLIVAR science to a wide range of issues.

Important Notice:

From January 1st, 1999, please direct all correspondence with the ICPO to:

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The contents of this issue of CLIVAR Exchanges highlight the wide range of preparatory and planning activities that are being carried out. I am pleased also to see an example of a practical application CLIVAR science.
I hope that soon we will have many more people putting their early science results in Exchanges.

International Project Office News

The turn of the year will also mark some significant changes in the staffing of the ICPO. The first happy announcement I can make is that in January Prof. Dr. Fredrick Semazzi will join the ICPO in Southampton as the CLIVAR Senior Scientist.

Prof. Dr. Semazzi was born in Uganda, April 28th, 1953 where he attended school at Kings College, Budo. He studied Meteorology at the University of Nairobi in Kenya. After graduating from the University of Nairobi, he was appointed Lecturer in the same department and soon took up a post-doctoral research associateship at NASA Goddard Space Flight Center on a National Academy of Sciences fellowship. In 1989/90, Dr. Semazzi was an Associate Director in the Climate Dynamics Program of NSF before taking up a faculty position as an associate professor in the department of mathematics and the department of Marine, Earth, and Atmospheric Sciences (MEAS) at the North Carolina State University. In 1997 he took sabbatical leave from NCSU and spent the year at the WMO Secretariat in Geneva, Switzerland, as head of the Climate Information and Prediction Services Project (CLIPS).

Dr. Semazzi's research focus is in climate modelling and the development of atmospheric numerical models. Over the last four years, he has been directing the development of a non-hydrostatic semi-implicit semi-Lagrangian variable resolution global atmospheric prediction model and adaptation of the nested modelling approach for regional climate prediction.

As many of you will already have seen from the last edition of Exchanges, we have recruited Mrs. Sandy Grapes as our CLIVAR Secretary/Executive Assistant in Southampton. Sandy comes to CLIVAR from her previous post in the University where she did a similar job for a large medical project. She had previously had experience in accountancy and so the CLIVAR finances should be in good hands. The Conference preparations have "thrown her in at the deep end" as we say, and this has meant that she has already corresponded with hundreds of CLIVAR scientists around the world.

The transition of the ICPO from Hamburg to Southampton has of course some rather sad consequences. The most significant of these is that at the end of the year Anne Stephan who has been the CLIVAR project administrator from the very start of the ICPO will be leaving CLIVAR. Anne brought her own international flair to the Office. She was widely travelled, spoke several languages and took a deep cultural interest in the people and affairs of the many nations she dealt with. I want to pay tribute to her contribution to the Project Office over the years. She has been most helpful to me, as she has been to the previous ICPO Directors, and to all of the CLIVAR community. I am sure that you join me in wishing her well for the future.

The link with Hamburg will not end completely since Andreas Villwock will continue to work as a project scientist until the end of 1999. All of the ICPO staff will be in Paris supporting the Conference.

In summary

So, as we enter 1999 we will start to match the national commitments to CLIVAR against the objectives outlined in the Initial Implementation Plan. We will be able to assess where CLIVAR implementation can progress rapidly and where more resources will be needed to meet our objectives. It promises to be an exciting time.

John Gould, Director, ICPO

The Economic Value of Seasonal Forecasts

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1. Introduction

Seasonal forecasting is essentially probabilistic. Recognising this, dynamically-based forecasts are now routinely made by running ensembles of coupled-model integrations. Standard scores can be computed from these ensembles to give objective measures of meteorological skill. However, it is often difficult to say whether a useful level of skill has been achieved. This is not surprising; for some users, an ability to forecast probabilities that are only marginally different from climatology may be very useful, for others, such probabilities might be almost worthless.

This note, part of a more extensive paper (Palmer et al., 1998), discusses the application of output from ensembles of seasonal integrations obtained as part of the European Union PROVOST (PRediction Of climate Variations On Seasonal and interannual Timescales) project, to an idealised decision model discussed in Katz and Murphy (1977). Effectively, utility is expressed in terms of the economic value of the forecasts to a hypothetical user.

The set of PROVOST data analysed in this study comprises 120-day 9-member ensemble integrations from four different atmospheric global circulation models, run over 14 winter seasons from the period 1979-93 (using as atmospheric initial conditions data from the ECMWF 15-year reanalysis). These four models are: the ECMWF IFS model, the UKMO Unified Model, and the Météo-France Arpège model at two different resolutions (T42 and T63). A 36-member multi-model ensemble has been constructed from these 4 sets of integrations.

2. Decision Model Analysis

Consider a potential forecast user who is able to take some specific protective or precautionary action against the impact of some meteorological condition or ‘event’ E. In the seasonal context, examples of E could be: the seasonal-mean rainfall is one standard deviation lower than normal, or seasonal mean temperature is above average. If the user was from the agriculture sector, then possible action could be to plant drought-resistant crops as a precaution against the occurrence of drought, or to spray for aphid growth as a precaution against the occurrence of a mild winter.
Suppose we have available an ensemble of seasonal forecasts. For each member of the ensemble, E is predicted to occur, or not to occur. The ensemble as a whole provides a forecast probability $p(E)$ of E, based on the fraction of ensemble members in which E occurs.

Suppose that taking precautionary action against the occurrence of E incurs a cost C irrespective of whether or not E occurs. (Crop spraying incurs a cost; planting drought-resistant crops may incur a cost because seed is more expensive, and possibly also because of reduced yield.) However, if E occurs and no precautionary action has been taken, then the user incurs a loss L (Crops lost through aphid damage, or drought). The user wishes to maximise economic return. By how much would the PROVOST data, if it were representative of real- time forecast information, have increased economic return?

To determine this, we summarise results from a simple decision-model analysis. First we need to determine probabilistic hit and false-alarm rates associated with E, given the PROVOST ensemble data. This can be done as follows. Suppose we assume that E is forecast to occur if the forecast probability exceeds some threshold, i.e. $p>p_t$ (and is forecast not to occur if $p<p_t$). By varying p_t we calculate the fraction of times $H = H(p_t)$ that E is forecast and E occurs, and $F = F(p_t)$, the fraction of times E is forecast and E does not occur.

On this basis, the user’s expected mean expense (per unit loss) $M(p_t)$, based on a decision to take precautionary action if $p>p_t$ can be shown to be

$$M(p_t) = F(p_t)\frac{C}{L}(1-\bar{o}) - H(p_t)\bar{o}\left(1-\frac{C}{L}\right) + \bar{o}$$

where $\bar{o}$ is the climatological frequency of E.
Given only $\bar{o}$, it can be shown that the user should always take precautionary action if $C/L < \bar{o}$, and never take precautionary action if $C/L > \bar{o}$. We now define the value $V(p_t)$ of forecast information to be a measure of the reduction in $M(p_t)$ over the mean expense using climatological information only. $V(p_t)$ is then normalised by the value of a perfect deterministic forecast. (Hence, for a forecast system which is no better than climate, $V = 0$; for a perfect deterministic forecast system $V = 1$). Again, it can be shown that

$$V(p_t) = \frac{min\left(\frac{C}{L}, \bar{o}\right) - F(p_t)\frac{C}{L}(1-\bar{o}) + H(p_t)\bar{o}\left(1-\frac{C}{L}\right) - \bar{o}}{min\left(\frac{C}{L}, \bar{o}\right) - \bar{o}\frac{C}{L}}$$

For a given user, i.e. for a given cost-loss ratio C/L, the optimal value for the user is given by $V_{opt}=max(V(p_t))$.

3. The Value of PROVOST data

Here we study the value associated with two very simple events: the 850hPa temperature anomaly is below normal ($E_{<0}$), and the 850hPa temperature anomaly is below -1K ($E_{<-1}$). The hit and false alarm rates are evaluated using forecast output from all extratropical northern hemisphere grid points.

In Fig. 1 (page 4), $V(p_t)$ and V_{opt} are shown for $E_{<0}$, as a function of C/L, based on ECMWF ensemble data only. The thin lines show the individual graphs $V(p_t)$ for p_t = 0.1,0.2, ... , 0.9. For small p_t, the graph indicates positive value for users with C/L between about 0.2 and 0.5, but no value for users with higher C/L. Conversely, for large p_t, $V(p_t)$ is positive for users with C/L between about 0.5 and 0.8. The envelope function V_{opt} shows value for all users with C/L between about 0.2 and 0.8. The ability of the ensemble forecast to provide this envelope function V_{opt} illus-

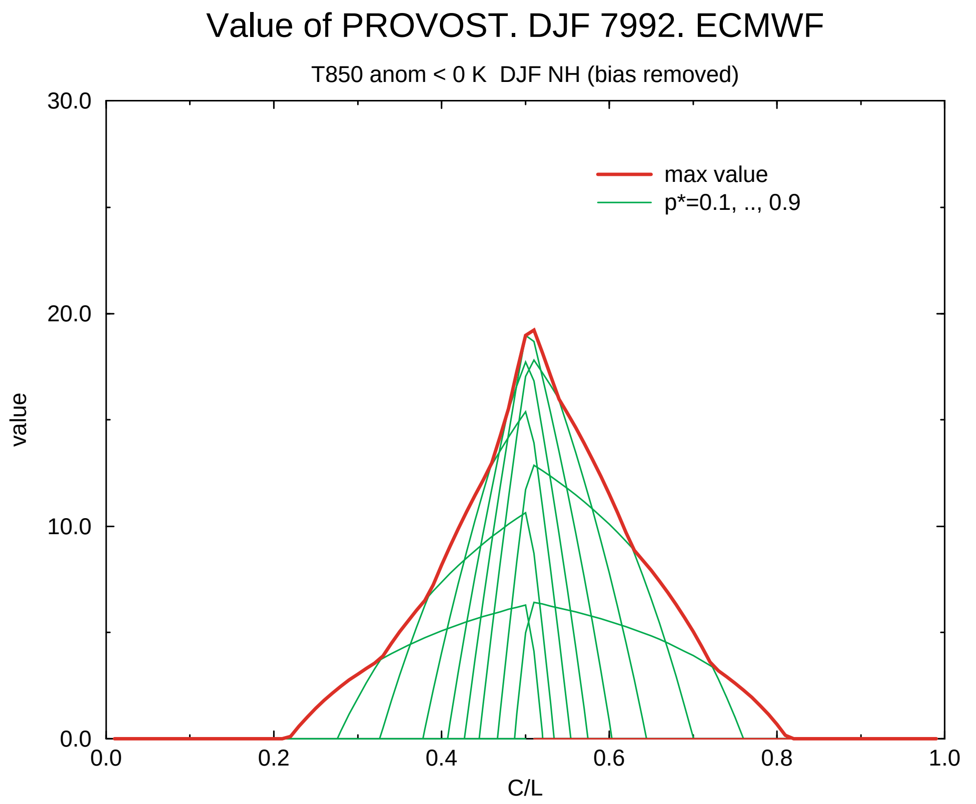

Fig.1: $V(p_t)$ for $p_t = 0.1, \ldots, 0.9$, together with the optimal envelope value V_{opt}, for $E_{<0}$. Extratropical Northern Hemisphere grid points.

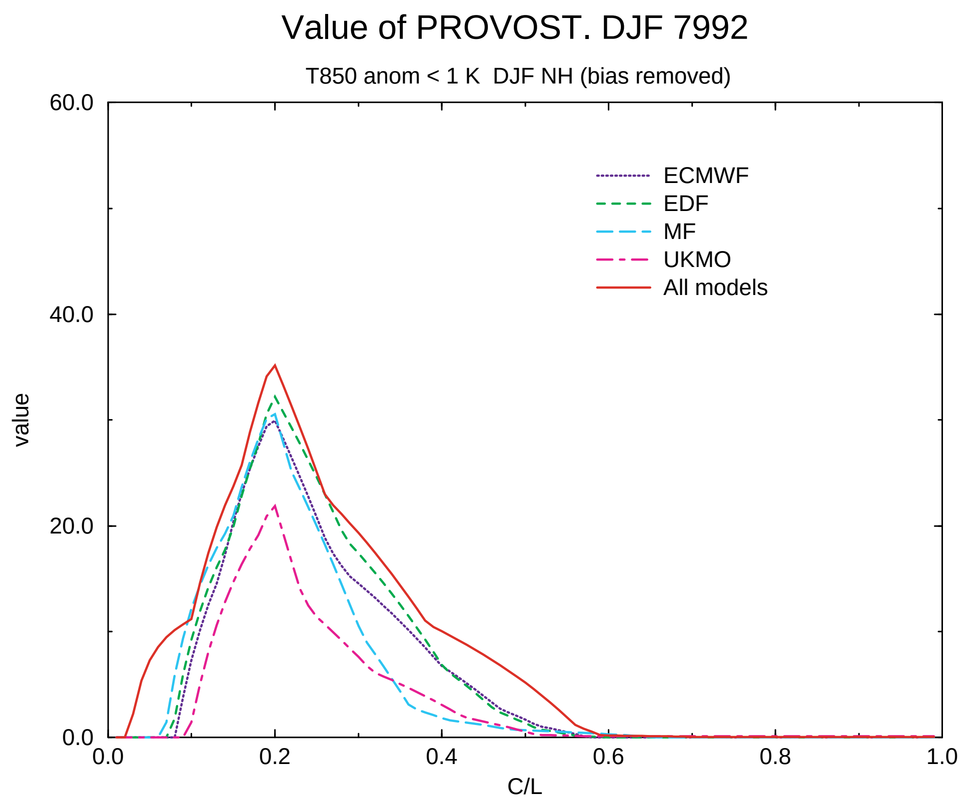

Fig.2: V_{opt} for $E_{<-1}$. Individual-model ensembles and multi-model ensembles. Extratropical Northern Hemisphere grid points.

trates the benefit of probabilistic forecasts over deterministic forecasts. The value of a deterministic forecast would be no better than that given by a single $V(p_t)$ curve; a deterministic forecast has only one hit and false-alarm rate for given E.

It can be noted that V_{opt} peaks for users with C/L ~ 0.5, which is the climatological frequency of $E_{<0}$. It can be noted that climatological information (which can only be used to say whether the user should either always or never take precautionary action) is of no value to users whose cost-loss ratio is close to the climatological frequency of E. In this sense it is not surprising that the value of PROVOST data is largest for users whose cost/loss ratio $C/L \sim \bar{o}$.

Fig. 2 (page 4) shows V_{opt} for $E_{<-1}$ for all the individual-model ensembles and for the multi-model ensemble. It can be seen now that maximum value occurs for users with C/L ~ 0.2, the climatological frequency of $E_{<-1}$. It can also be seen that the value of the multi-model ensemble data exceeds that of any of the individual models for most cost/loss ratios between 0 and 0.6. Note that the scale of the ordinate axis is different in Figs. 1and 2. The value of forecasts of the $E_{<-1}$ event is higher than that of the $E_{<0}$ event for $C/L \sim \bar{o}$.

To be more concrete about these results, suppose that a user with C/L ~ 0.2 estimated that (s)he could save 1 million dollars through precautionary action assuming a hypothetical perfect deterministic forecast of $E_{<-1}$. Then, on the basis of the PROVOST multi-model ensemble data, about 300,000 dollars could actually be saved.

As shown in Palmer et al. (1998), value is improved if one restricts to ENSO years.

Discussion

We have considered two rudimentary events, and have evaluated them over a rather extensive region. Specific users may well require more complex and/or specific events and the user's domain of interest will be much smaller (in principal it may be restricted to a single model grid point). However, for all such events and domains the techniques outlined in this paper can be readily adapted. Of course, the data used in this study is somewhat idealised since the integrations have been made with observed prescribed sea surface temperatures. The next phase would be to apply this type of decision-model analysis to output from coupled ocean-atmosphere model ensembles.

One result from the analysis is that multi-model ensembles generally have higher value than single model ensembles. From a practical point of view, this stresses the need for a synthesis of the available seasonal forecasts into a single multi-model multi-initial-condition ensemble probability forecast.

Acknowledgements

We acknowledge the help of Jean-Yves Caneill (Eléctricité de France), Michel Déqué (Météo-France) and Mike Harrison (United Kingdom Meteorological Office), for assistance in planning these ensemble experiments, and making data from their models available. This work was supported by the European Union Environment and Climate Programme under contract CT95-0109.

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Dr. Tim Palmer got his PhD from Oxford University in relativity theory. In the late 1970 he moved to the UK Met. Office. In the early 1980s. he spent one year at the University of Washington. Since the mid 1980s he has been affiliated with ECMWF. Currently, Dr. Palmer is Head of the Predictability, Seasonal Prediction and Diagnostics Section. Over the years, he has worked in a variety of different areas in atmospheric and climate dynamics. Most of his scientific interests now relate, one way or another, to predictability issues, from days to decades. Dr. Palmer is the coordinator of the EU PROVOST project on seasonal prediction and member of the CLIVAR Scientific Steering Group.

U.S. Appoints Science Steering Committee

United States federal agencies understand that the CLIVAR science programme offers an opportunity to cooperate in a comprehensive study of climate variability and change. The Department of Energy (DoE), National Aeronautics and Space Agency (NASA), National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF) have formed an inter-agency coordinating group for CLIVAR as part of the U.S. Global Change Research Program. This agency cooperation is made necessary by the breadth of the CLIVAR programme that aims to understand the causes of climate variability, to improve predictability of this variability, to extend pre-instrumental climate records into the past, and to understand and predict the climate changes caused by growth of radiatively active gases and aerosols in the atmosphere. While individual agencies have unique missions, the CLIVAR goals are shared by the inter-agency group as scientifically timely and important.

The inter-agency group has appointed a Science Steering Committee (SSC) to advise on implementing the U.S. effort in CLIVAR. U.S. scientists support all three CLIVAR programmes (GOALS, DecCen and ACC) and there is interest and activity in all the CLIVAR Principal Research Areas (PRAs) as well as in connecting and expanding some PRAs. The SSC has recommended participation in the full international effort with a focus on understanding and predicting seasonal-to-interannual climate variability but with appropriate efforts in decadal variability and anthropogenic change.

Within the U.S., the best developed plans address prediction of ENSO (G1), variability of the Pan-American Monsoon (G3), decadal modulation of ENSO (bridging G1 and D4), and seasonal-to-decadal variability in the Atlantic sector (G1, D1, D2 and D3). Efforts in seasonal-to-interannual variability include global modelling and empirical studies coupled with continuation of the TAO Array plus enhanced observations in the Atlantic and Pacific Oceans. Pan-American monsoon studies are integrated with the VAMOS programme and with new tropical ocean observations. Modest expansions of the modelling, empirical and observational work in these efforts will support studies of decadal variability (D1-D4). A majority of the U.S. work in Anthropogenic Climate Change will be based on a coordinated modelling effort. Planning and pilot studies for the Asian-Australian monsoon (G2) will be initiated. Other areas, such as African Climate Variability (G4) and extending studies of the thermohaline circulation (D3) to include changes in the Arctic, are of great interest and current activity, but the SSC hopes other nations will take the lead in developing and implementing a strategy to satisfy CLIVAR objectives in these areas.

Many ingredients of research in the individual PRAs are common to them all. The U.S. should support integrating efforts such as development of models and data assimilation techniques, design and implementation of improved observing systems, and continuation of present satellite and in-situ observations. CLIVAR research is interdisciplinary, so close cooperation is required with operational activities in the World Weather Watch, GCOS, GOOS, GODAE and Argo and with complementary research programmes such as GEWEX and PAGES. In particular, the U.S. CLIVAR programme is predicated on continuation and evolutionary improvement of (a) satellite and in situ measurements that support operational analyses of the atmosphere, (b) satellite measurements of sea surface topography and surface winds over the ocean, and (c) the TAO array.

The SSC has recommended the following specific elements of U.S. CLIVAR:

A. Global Seasonal-to interannual predictability - ENSO and Monsoons -

The present efforts in diagnosis and experimental forecasting of ENSO should continue. Maintenance and evolution of the TAO array and satellite measurements of the surface wind field and sea surface topography are crucial to this effort. Changes to these systems should have sufficient overlap for careful assessment. Deliberate expansion of studies of the American Monsoon should proceed, extending first to the Pacific cold-tongue and stratus region because of its relevance for ENSO prediction, and then to the American Monsoon region and into the tropical Atlantic. Studies of the Austral-Asian Monsoon system will proceed through a phased approach, beginning with pilot studies and development of international collaborations.

B. Decadal Modulation of ENSO

The U.S. should contribute significantly to study of decadal modulation of ENSO in the Pacific sector throughout the life of CLIVAR. This study should be built around a coordinated observational and data assimilation study and include empirical and paleoclimate studies, and experimentation with a spectrum of climate models. GODAE and its companion profiling-float programme Argo in the Pacific sector should be supported as a contribution to CLIVAR.

Continuation and evolution of TAO array time series are vital elements of this programme.

C. Climate variability in the Atlantic sector

The U.S. should contribute significantly to the study of climate variability in the Atlantic sector, focusing specifically on the North Atlantic Oscillation and Tropical Atlantic Variability. A coordinated upper ocean observing system in the tropical Atlantic extending throughout the North Atlantic Ocean and coupled with a basin-wide ocean data assimilation effort will be required. Modelling and limited observations to define and understand climate-scale variability in the deep ocean should be included.

D. Sustained observations

Success of CLIVAR depends, in part, on the continuation and enhancement of the atmospheric observing network (including the World Weather Watch network) and this should be a high priority for U.S. CLIVAR. Improvements are needed to this and other observing systems. A legacy of CLIVAR should be a Global Climate Observing System that is evolutionary, providing observations for operational and research purposes and to assess the impact of its elements. Priorities for observations that are not yet available in an operational context are:

- Enhancement of the atmospheric weather observation network to make it adequate for long term monitoring of climate variability;
- Measurements of temperature and salinity in the upper 1500 meters focused in the subtropical Pacific (35^oS to 40^oN) and Atlantic (35^oS to 65^oN);
- Satellite altimetry of sufficient accuracy (1-2 cm) and duration (at least the next 20 years) to detect decadal changes in ocean circulation, the polar ice sheets and mean sea level;
- Sustained, accurate measurements of surface vector winds over the ocean;
- Complete and accurate measurements of surface fluxes of heat, freshwater, energy and momentum at select ocean and land sites, including improved measurements of cloud properties and soil moisture;
- Collection of long time series from the ocean at select Eulerian stations and from repeat ocean sections.

Two implementation activities are planned. First, instruments should be deployed to meet the needs of particular CLIVAR PRAs. Second, in cooperation with international and non-CLIVAR programmes, U.S. CLIVAR should build toward a sustained, global climate observing system. In both these activities, U.S. CLIVAR should promote strong ties between observational, modelling and data assimilation activities. In particular, the upper ocean observing system should evolve in the context of vigorous data assimilation activity. There must be free, open and timely exchange of data from all sustained observing systems.

E. Climate Modelling

In addition to a continuing aggressive programme of numerical experimentation, effort should be put into improving coordination of modelling work. Effort should be made to facilitate open and ready access to well-documented models, data assimilation systems, simulations, and observations. A common programming paradigm should be adopted to facilitate exchange of model modules such as physical parameterisations.

F. Data Set Development

A fundamental objective of the U.S. policy on data management should be the free, open and timely exchange of CLIVAR related data and products. The U.S. should have a strong policy of keeping as much data as possible in the public domain and limiting the time that data can be restricted. Support should be given for development of comprehensive, long-term data sets by improving the quality and volume of the historical database through data archeology, supporting the development and evaluation of data sets, development of integrated proxy records and continuing to reanalyse historical data and satellite-based products for the atmosphere and ocean.

The SSC will be working vigorously to coordinate the plans of various programmes and individual efforts that will make up U.S. CLIVAR.

Present membership is: David Battisti (Univ. Washington) and Russ Davis (Scripps Institute of Oceanography) (co-chairs), Tom Ackerman (Pennsylvania State Univ.), Robert Dickinson (Univ. Arizona), Jim Hurrell and Jeff Kiehl (National Center of Atmospheric Research), William Kessler (NOAA Pacific Marine Environmental Lab.), Michele Rienecker (NASA Goddard Space Flight Center), Walter Robinson (Univ. Illinois), Peter Schlosser (Lamont Doherty Earth Observatory), Jagadish Shukla (Center for Ocean-Land-Atmosphere Studies) and Robert Weller (Woods Hole Oceanographic Institution).

R. Davis (Scripps Institution of Oceanography, USA),
D. Battisti (Univ. of Washington, USA)

On the Support of Ocean Modelling for Climate Research:
-A report on progress and proposed developments-

D. Webb (Southampton Oceanographic Centre, UK), J. Willebrand (U. Kiel, Germany)

Summary

This document discusses how future development, testing and validation of ocean models for climate research may be best encouraged and supported by the WMO and WCRP. It is based on the successful "Workshop on Ocean Modelling for Climate Research" held at NCAR in August 1998.

Background to the Workshop

The ocean is a key component of the climate system, having a role both in moderating and in generating climate anomalies. The moderating effect comes primarily from the large thermal inertia of the ocean which allows it to store a significant amount of heat in its surface layers. This works even if there are no currents in the ocean.

In contrast climate anomalies are often produced by ocean currents. These can transport the stored heat of the ocean surface layers over large distances, the heat then released producing significant effects on the climate system. Thus ocean currents are responsible for the El Niño and for the present warm climate of Western Europe. They are also responsible for many of the major climate changes in the Earth's past.

For these reasons the ocean component is always an important part of the coupled models used for climate change prediction. This is why the WCRP has encouraged the development, improvement and testing of ocean models for many years through the WOCE and TOGA programmes. The WOCE programme in particular has been responsible for the development of ocean models suitable for the mid- and high-latitude oceans and for long climate runs.

However WOCE has now entered its final analysis stage, the WOCE NEG is no longer in existence and many of its responsibilities are being transferred to CLIVAR and the WGCM. As part of this process, WOCE and the WGCM jointly proposed and supported a workshop on "Ocean Modelling for Climate Studies". As well as continuing to encourage the improvement of ocean models and the transfer of knowledge to the climate modelling community, it was hoped that this would also help to clarify how future support for ocean modelling should best be organised within the WCRP.

The Boulder Workshop

The Workshop on "Ocean Modelling for Climate Studies" was held at NCAR in the USA between August 10th and 13th 1998. The meeting was organise by Dr. C. Boening of the Alfred Wegener Institute, Bremerhaven, Germany, with the local NCAR support of Dr. P. Gent and Dr. W. Large.

The workshop brought together sixty four invited experts representing the climate modelling, ocean modelling, and observational communities. The workshop focused on the problem of realistically representing the ocean's role in climate variability at decadal time scales. It tried to understand how well different aspects of ocean dynamics need to be represented. It also tried to see how current and future observational datasets could be used to guide the development of improved models.

A summary report of the meeting is attached. A full report will be published later through the WCRP system. During the meeting there was a detailed and often animated discussion on a wide range of relevant issues. We concentrate here on three areas relevant for planning purposes. These are the problems of model resolution, the parameterisation of processes in coarse resolution climate models and the proposals for a new ocean model intercomparison project.

Model Resolution

In recent years, many of the major improvements in ocean models have resulted from advances in available computer power. Previously there had been insufficient power for running ocean size models which could resolve the Rossby radius of the ocean. However, results from a number of such models are now available and these have stimulated oceanography in a number of important areas.

First, by convincing the sea going community of the realism of ocean models, they are encouraging detailed validation studies against field data. These in turn are leading to further improvements in the models.

The high resolution model results have also stimulated a number of studies of the effect of resolution on model behaviour. One area of concern is the indication from a number of experiments that, as model resolution increases, the total heat transport of the ocean continues to increase. The reason for this is being investigated, but it occurs in all types of models and appears to be connected with improved realism of both the gyre and thermohaline circulation of the ocean. It may also be connected with the greatly improved representation of ocean topography that is now possible.

The high resolution models also allow detailed studies of thermohaline processes which have long term effects on the climate system. These include deep convection at high altitude and the overflow of water from the Nordic and Mediterranean seas into the Atlantic. However, many of these processes have very small scales and, although the increase in model resolution has helped, they are unfortunately still represented poorly in even the highest resolution models.

Parameterisation in Coarse Resolution Models

Although the increase in computer power allows single runs of high resolution models, coupled climate models continue to use coarse resolution oceans which do not resolve the Rossby radius. This is because climate studies require long and repeated runs which often last many hundreds of years.

An advantage of combining expertise from both types of model is that results from the high resolution can be used to validate coarse resolution model results. They can also be used to develop better parameterisations for the coarse models. One of the most successful of these is the Gent and McWilliams parameterisation scheme for ocean eddies and this attracted a lot of attention during the workshop.

There was also lengthy discussion of deep convection, overflow and bottom boundary layer schemes suitable for both high and coarse resolution models. Recent intercomparisons of ocean models show that large differences in the final results are often associated with the poor representation of near bottom effects.

A related area of concern is the reduced heat transport found in low resolution models. Further research is needed on why this occurs and how it may be overcome. As with other errors, this produces significant changes in the mean state of the ocean which in turn affect the response of the ocean to changes in the atmospheric forcing.

Key processes occurring at just one or two grid-points.

Studies of ocean models indicate that the thermohaline circulation is often dominated by poorly represented processes which are taking place at a very small number of oceanographic grid points. Thus deep convection often only occurs at one or two grid points in the North Atlantic. Mixing in the overflows may be dominated by just one gridpoint. Under these conditions there is little chance for errors in different parts of the model to cancel.

As a result, model performance can often depend on a fortuitous choice of parameters. For this reason at present we have little confidence that a model that works well under one set of conditions will work well under different conditions due, say, to climate change.

Given the additional problems in parameterising these processes and the other effects of model resolution it is believed that the coarse resolution ocean models presently used for climate research are suspect. As a consequence of this, predictions of large changes in ocean circulation and the state of the ocean based on the behaviour of such models should be treated with caution.

The meeting also expressed concern about the methods used in climate change research where the system is started from an “equilibrium” initial condition in which the ocean state is far removed from the present ocean. As the climate change runs are generally shorter than the initial run required to reach this ‘equilibrium state’, it seems likely that studies starting from the present ocean state would be more accurate and informative.

Ocean Model Intercomparison Project

The possibility of starting a new Ocean Model Intercomparison Project (OMIP) was discussed. Reports were given by people involved in earlier OMIP projects, the most comprehensive of which was the European DYNAMO project. This compared the performance of high resolution level, isopycnic and sigma co-ordinate models of the North Atlantic.

There were concerns about the large amount of effort required and possible lack of publications from such a project. However, previous experience with such projects had shown that if they are tightly focused and organised, they often lead to useful and publishable results. Thus the CME, DYNAMO and Met Office intercomparisons had all produced useful results and stimulated further model developments.

For the future two possibilities were discussed. The first was to encourage self-organising OMIPs like the ones referred to above. The second was to set up fixed framework with specified model extent, surface forcing and time scale and which provides resources for storage and analysis of results. A combination of both approaches may be possible.

One attractive scenario is to encourage tests of global models using reanalysed surface forcing data. Such runs would be limited to periods of 20 years or so, allowing high and coarse resolution models to be intercompared and also emphasising validation against recent oceanographic measurements.

Future support for ocean modelling

The 1998 workshop was very productive. There was much discussion of the problems facing climate modellers and it is expected that this will help stimulate further improvements in ocean model performance. However, it was also obvious that more thought needs to be given to how such initiatives be continued in the future. When WOCE finishes it could be taken on as a responsibility of the WGCM, but although very important, it remains only a minor part of the WGCM's broad range of responsibilities.

For this reason we believe that a new group is required which can give its full attention to the problems discussed above and to other problems that arise. We propose that the new group be set up, under WGCM and WOCE, and that it should be given responsibility for the development of ocean models for climate research. The area of responsibility needs to include decadal and longer time scales and also include ocean processes at mid- and high-latitudes. Thus we would expect the group to collaborate with the Arctic NEG in validating ocean models under ice, but it should not clash with the tropical El Niño interests of the CLIVAR-NEG-1.

The terms of reference of the new group could include:

1. To stimulate the development of ocean models for research in climate and related fields, with a focus on decadal and longer time scales at mid- and high-latitudes.
2. To encourage investigations of the effect of model formulation on the results of ocean models, making use of sensitivity studies and intercomparisons.
3. To promote interaction amongst the ocean modelling community and between this and other communities through workshops and other activities.
4. To stimulate the validation of ocean models when used in stand alone mode and as part of a coupled ocean-atmosphere model, using oceanographic data and other methods, and to advise on the observational requirements of such studies.
5. To publicise developments in ocean models amongst the climate modelling community.
6. To collaborate with other WMO committees in areas of overlapping responsibility.
7. To advise on ocean modelling and related issues and to report on its activities to the WOCE-SSG and the JSC/CLIVAR WGCM.

Second session of JSC/CLIVAR Working Group on Coupled Modelling

Melbourne, 16-17 October 1998

The second session of the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) was held in conjunction with two other relevant meetings which certainly helped in setting the scene for the WGCM discussions. The first of these was the tenth annual modelling workshop of the Australian Bureau of Meteorology Research Centre, 12-13 October 1998, and which, taking advantage of the visit of members of WGCM to Melbourne, was on the subject of coupled climate modelling. A large number of coupled modelling groups were represented and participants were treated to comprehensive presentations of the coupling process, air-sea interaction and coupled model initialization, simulations of decadal and centennial variability in coupled models, and, finally, accounts of recent results from and diagnoses of climate change experiments.

The second meeting was a workshop on the Coupled Model Intercomparison Project (CMIP), 14-15 October, that was organized by WGCM itself to review the latest results from the models involved in CMIP, to assess findings from the intercomparison subprojects, and to discuss the future directions for CMIP. In various presentations, it appeared that the absence or the inclusion of flux adjustments in models was not a major factor in the representation of such aspects as the seasonal cycle or Pacific variability. In many models, although several phenomena seen in the coupled ocean-atmosphere system such as the North Atlantic Oscillation, El Niño-like variability, and the Antarctic Circumpolar Wave are reproduced, the simulation of high and low frequency climate variations models is generally less than observed. As to the future of CMIP, the view of participants was that much more remained to be done fully to exploit the data base of results that had now been gathered and, possibly, by collecting additional subsets of data in CMIP1 and CMIP2, rather than embarking on a third phase of CMIP in which new transient coupled model integrations, albeit with more realistic scenarios, would be proposed.

The WGCM took these views fully into account when it came to considering the future planning for CMIP, the first principal agenda item at the WGCM session, 16-17 October. In particular, it was agreed that a pilot project should be organized in which data sets at higher temporal resolution could be assembled for specific time-periods/domains for other studies such as model simulations of extremes, and of synoptic and intra-seasonal variability. In addition, updated or new CMIP1 or CMIP2 integrations would be accepted. In the future, consideration will be given to a general request for additional parameter fields (e.g. to enable the diagnosis of cloud forcing). The evolution of proposed scenarios of greenhouse gas changes and aerosol loading will also be monitored in preparation for a possible third phase of CMIP that might be launched in 1999 or 2000.

Further results were also available from the intercomparison of slab-ocean model doubled CO_2 equilibrium experiments, organized by WGCM. The pattern of response of the zonal average change of air temperature, water vapour and clouds was similar among models, but there were significant disagreements in the amplitude of the changes and their detailed distribution. The increase in downwelling long-wave radiation in the doubled CO_2 atmosphere was generally compensated by increases in surface temperature and evaporative cooling. Zonal average precipitation changes show broadly greater tropical and less mid-latitude precipitation although there were major discrepancies at regional and local scales.

WGCM noted with interest the main conclusions and recommendations from the Workshop on "Ocean Modelling for Climate Studies", held in Boulder, CO, USA, in August 1998 (see previous article). The resolution required in an ocean model satisfactorily to represent ocean eddy heat transport and to resolve key processes such as overflows and deep ocean convection (which may occur at only one or two grid points and dominate the long-term behaviour of the model) continues to be an outstanding issue. To encourage investigations of the effect of model formulation on ocean simulations, requiring organization of sensitivity studies and model intercomparisons, WGCM saw merit in the proposal to set up a joint WGCM/WOCE ocean modelling group. The direct relationship WGCM has been building up with the ocean modelling community, essential in fostering the refinements needed in the ocean components of coupled climate models, would be maintained by the regular participation of at least the chairman and another representative of the ocean modelling group in WGCM sessions.

WGCM also reviewed the latest results from the Paleoclimate Modelling Intercomparison Project (PMIP). In the case of the mid-Holocene climate, PMIP simulations show a northward displacement of the desert-steppe transition zone over North Africa, qualitatively consistent with estimates inferred from detected biome shifts, but strongly underestimated in extent, mainly because of the omission of the vegetation, surface hydrology and ocean temperature feedbacks in the climate system in the simplified PMIP experiments. Consideration is being given to rerunning the experiments with coupled ocean-atmosphere-vegetation models. In the experiments aimed at simulating the Last Glacial Maximum, the prescribed sea surface temperatures (based on CLIMAP estimates) appear to produce too weak a cooling over land. When sea surface temperatures are computed with a mixed-layer ocean model, cooler ocean and land conditions, in agreement with available data, were generated in four out of nine simulations. The WGCM encouraged the continued development of this activity. More generally, the need to extend the climate record further back in time by exploiting proxy data was strongly stressed. In particular, a much higher time resolution of climate variability that has occurred over about the past 1000 years was necessary. The WGCM wished its views in this respect to be placed before the planned joint PAGES/CLIVAR meeting in 1999 where the paleodata and modelling communities would consider how to establish an appropriate record over the last millennium.

Two significant new efforts were launched by WGCM. Firstly, an informal co-operative investigation of decadal climate variability, based on experimentation with global coupled atmosphere/ocean models, was proposed. An ensemble of at least three, but preferably more, forecasts of at least 50 years in length should be performed (probably from identical ocean states but with atmospheric states separated by at least one full day). A range of predictability measures would be collected. Secondly, in collaboration with the IGBP Global Analysis, Interpretation and Modelling (GAIM) activity, concrete steps were taken towards assessing how the carbon cycle may be reproduced by using surface carbon flux parameterisations in conjunction with physical climate models. Initially, in appropriately designed AMIP and CMIP diagnostic sub-projects, inferred air-land fluxes of carbon for the period 1979-1998 would be investigated. It was further proposed that interested groups be invited to carry out transient integrations (up to a hundred years or so) using coupled atmosphere-land-ocean-carbon models. In these experiments, the fossil fuel emission would be specified (not the atmospheric carbon dioxide concentration as is now the case). The simulated change in carbon dioxide concentration (dependent on the surface carbon-flux parameterisations) would be computed and would be allowed to interact with the model's physical climate representation, and the overall changes in model climate and carbon dioxide concentration tracked.

All participants expressed gratitude and appreciation to the Australian Bureau of Meteorology Research Centre for hosting these three meetings, the excellent organization and arrangements, and the facilities and hospitality offered.

R. Newson, Joint Planning Staff of WCRP

A Decade of Progress on the Western Pacific Warm Pool Coupled System: The CLIVAR/GEWEX COARE98 Conference

More than 150 meteorologists and oceanographers from eight nations met in Boulder, Colorado from 7-14 July, 1998 to share results of their research using TOGA COARE (Coupled Ocean-Atmosphere Response Experiment) data, and to assess the impacts of the experiment which was conducted in the western equatorial Pacific from November 1992 through February 1993. The team of COARE scientists collected unique, high-quality observations of the upper ocean, the air-sea interface, and the atmosphere in the warm pool region. Based on the Conference, a much better understanding of the coupled ocean-atmosphere system in the tropics will result.

Scientific sessions addressed

- large scale coupled aspects of the Western Pacific warm pool (including its east-west migrations as part of ENSO) including predictability;
- the dynamics and air-sea interactions of the 30-60 day intraseasonal oscillation (ISO), which is particularly strong over the warm pool;
- precipitation, radiation and clouds, and the organization of convection;
- diurnal variability in the warm pool system;
- air-sea fluxes and budgets of heat, freshwater/salt, and momentum;
- warm pool response to wind and buoyancy forcing;
- parameterisations, and multiple scale interactions.

Invited presentations reviewed progress towards the four goals of COARE, and assessed the legacy of COARE for CLIVAR, GEWEX, numerical weather prediction, satellite remote sensing, and in situ observing technology. Significant progress has been made in synthesizing the results of COARE research, and a substantial legacy has been left in the form of the datasets, the literature (more than 200 papers to date), improvements to the hierarchy of models, and improvements to observing systems and their application (e.g., new bulk flux algorithm improves use of bulk met observations; new satellite retrieval methods).

Highlights of the scientific discussions were:

- closure of interfacial, ocean and atmosphere budgets of heat and moisture to better than 10 Wm^{-2} and 25% of the rainrate, on biweekly and longer time scales
- determination of flux component phasing during the ISO and the identification of the importance of air-sea interaction within the ISO
- the success of cloud-resolving models at simulating realistic cloud structures and surface fluxes
- significant progress towards improving the physical basis for convective parameterisations in atmospheric GCMs using COARE observations together with cloud resolving and single-column models
- evidence for the potential importance of high frequency forcing, such as diurnal heating, in governing longer-term SST tendencies
- demonstration of the need to consider the role of freshwater flux, the depth-dependent absorption of solar radiation, and the shallow thermohaline variability when predicting SST in the warm pool
- new insights into mixing processes and the evolution of turbulence in the upper ocean, made possible by the abrupt capping of the upper ocean by stable, fresh layers during heavy rain
- the relative importance of air-sea interaction and wind-forced Kelvin waves in the warm pool as compared to reflected Rossby waves during the onset of some ENSO warm events, including the 1997-98 event
- the impact of the COARE dataset and resulting parameterisations on numerical weather prediction analyses and forecast skill
- the resolution of the global Vaisala rawinsonde humidity problem discovered during COARE

A remarkable aspect of COARE'98 was that many new investigators joined those who had spent much of the last 10 years to develop, conduct and analyse the experiment. Significant modelling efforts are underway, motivated in large part by the high quality dataset collected during the COARE IOP, and early results are extremely encouraging. Observers are becoming involved in some of these efforts as full partners in numerical experiments to test hypotheses which COARE was designed to test. Oceanographers and meteorologists renewed their collaborative efforts to understand and model the processes important to the coupled warm pool system. The free and open access to the data from the IOP initiated by the COARE

Project Office has led to its wide-spread use.

A committee worked prior to and during the meeting to specifically identify gaps and unfulfilled objectives, and to suggest methods for dealing with them. Considering these as opportunities for programmes such as CLIVAR and GEWEX, the most compelling are:

- Development of an improved convection algorithm for atmospheric GCMs to link with the COARE Bulk Flux algorithm
- Identify the source of dry air intrusions in the warm pool region, and their influence on the troposphere and convection.
- A quantitative description of warm pool oceanic variability on 100km to 1000km scales.
- Inclusion of the hydrological cycle in coupled models that are capable of simulating mean and varying conditions in the warm pool region.
- Understanding the principal mechanism of air-sea coupling in the ISO.
- Understanding of convection under suppressed conditions and the transition to the active phase.
- Accurate time series and small space/time scale flux fields for forcing ocean models and for validating atmospheric models.
- Examination of low wind conditions and horizontal variability of SST.
- Assessment of the importance of meso-scale convective systems in controlling the local and remote evolution of upper ocean temperature, salinity and current structure.
- Development of a reference surface for altimetry analysis of surface currents
- Inadequate salinity measurements to fully explore the salinity variability and influence on ocean dynamics.
- Transitioning the COARE bulk flux algorithm to operational NWP models, and the scaling of the parameterisations to larger domains with extension to wind speeds >12 m/s.
- Insuring that results from COARE are used to improved turbulence, convective and radiative parameterisations in operational and coupled climate models.
- Explicit consideration of the optical properties of the upper ocean and their role in governing SST.
- Extension of COARE results and parameterisations to other regions (eastern Indian ocean, eastern Pacific)
- Comparison of COARE data and results to that of other field experiments past and future to expand the range of conditions that can be studied.
- Determination of the role of microphysical cloud processes in convection.
- Meso-scale data assimilation of shipboard radar data
- Implementation of rawinsonde humidity correction procedures for the global historical dataset

Focused working group meetings continued or initiated efforts to address some of the major remaining challenges, and to expand the applicability and application of COARE results. The GEWEX Cloud Systems Study Working Group 4 met during the conference. A group met twice to develop a proposal to the WCRP to set up a Coupled Ocean-Atmosphere Boundary Layer working group to expand on the success of COARE and focus on continued improvements in the boundary layer parameterisations in climate and NWP models, and in air-sea flux climatologies. Another group met to develop plans towards assimilation, analysis and modelling of COARE upper ocean data.

In summary, the consensus of COARE98 was that COARE has been a huge success. The design and execution of the COARE IOP was successful, and the investment made in the resources that collected the data are beginning to have a tremendous return. While certain objectives remain to be met, progress has been rapid. It is believed that most of the identified remaining challenges are highly relevant to the scientific objectives of CLIVAR and GEWEX, so it is hoped that these programmes will continue to assimilate COARE results and investigators. The proceedings of COARE98, including the review papers and extended abstracts of the contributed papers, will be published as a WCRP Report.

Roger Lukas, Univ. of Hawaii, USA
Frank Bradley, CSIRO, Australia

Euroclivar - 6th Session

The Euroclivar committee has held its sixth meeting in Horley, South England on 29 and 30 October 1998. The aim of that meeting was the formulation of a final set of recommendations for a European contribution to CLIVAR. A draft document had been available for some time, and had been presented already in April, at the European Geophysical Society meeting in Nice, and in October, at the European Climate Science Conference in Vienna. However, the report needed to be completed with results from recent workshops. In total, Euroclivar has organised eight workshops:

- Atlantic Ocean DecCen Variability (in parallel with the CLIVAR Villefranche meeting)
- Cloud Feedbacks and Climate Change

- Past Climate Data
- Climate Change Detection and Attribution
- The Role of the Atlantic in Climate Variability
- African Climate Variability
- Climatic Impact of Scale Interaction for the Tropical Ocean/Atmosphere System
- Data Assimilation in Ocean Models

Reports of these workshops are either available, or in print.

The Euroclivar document starts by spelling out the European interest in CLIVAR. The arguments are:

1. Natural fluctuations of the climate of Europe have many very significant consequences for safety, health, infrastructure, agriculture, energy, economy.
2. Natural climate fluctuations elsewhere in the world have European implications through geophysical, socio-economic and political mechanisms.
3. Improved prediction and detection of anthropogenic climate change will provide a firmer scientific basis for active emission, mitigation and adaptation policies.

It then continues with an identification of the main scientific issues. In particular, Euroclivar recommends that high priority be given to the following topics:

1. European and Atlantic variability;
2. Global teleconnections; and
3. Anthropogenic climate change.

The executive summary ends with the following recommendations:

"To achieve the Euroclivar objectives, the establishment of an integrated observational network is imperative. This network, to be implemented in cooperation with nations adjacent to the Atlantic, should include:

1. an extensive network of profiling floats in the Atlantic;
2. an operational tropical Atlantic array of moored atmosphere/ocean observing stations (PIRATA);
3. basin-wide measurements of the Atlantic water mass and circulation variability at critical latitudes; continuation, at the present level, of the ocean/atmosphere observations with voluntary observing ships; and
4. continuous contribution of satellites to the global coverage of the ocean and atmosphere.

In addition, past climate variability needs to be reconstructed, using both the instrumental and the paleoclimatic records.

Reliable regional climate change predictions cannot be achieved without enhanced European collaboration and substantial increases in computing resources. These are needed so that multi-century simulations can be made with sufficient complexity, that important climatic features, physical processes and regional details are resolved. In addition, ensembles of integrations must be made to estimate the impact on climate predictions of uncertainties in initial conditions and model formulation. The computational requirements for such simulations cannot be met from purely national resources. It is therefore strongly recommended that a European Climate Computing Facility be established."

The detailed recommendations can be found in Anderson et al. (1998) and also on the Euroclivar website (http://www.knmi.nl/euroclivar). Euroclivar is now looking forward to the implementation of its recommendations under the Fifth Framework Programme. Euroclivar is supported by the European Commission under the Environment and Climate programme (1994 - 1998).

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G. Komen, KNMI, De Bilt, The Netherlands

The NASA Workshop on Decadal Climate Variability

Williamsburg, VA, USA; 22-25 September 1998

Introduction

The study of natural variability of the climate system at decadal- multidecadal time scales has a long history but is receiving increased attention over the last two decades. During much of its history, the study of decadal climate variability was mired in controversy because the majority of decadal climate variability studies were confined to sunspot cycle-regional climate variability correlations. By focusing on global and basin scale decadal climate variability without a presumed reference to possible causes, this field has now emerged from this controversy and is fast becoming an important area of climate research because
1. decadal-multidecadal climate variability affects the lives of several billion people via its long-lived effects on agriculture, water resources, fisheries, and public health; 2. ENSO and the Asian-Australian monsoons, and their predictabilities are known to vary at decadal-multidecadal time scales; 3. natural climate variability

at decadal-multidecadal time scales has the potential to interact with anthropogenic climate change; and 4. it is possible/likely that some societies are more vulnerable to decadal climate anomalies than to shorter-term climate anomalies because of those societies' resilience against shorter-term variability.

As an indication of its importance, several national and international Workshops on decadal climate variability have been organized in the 1990s to assess the progress of research in this area and to develop research programmes. One of the major components of the International CLIVAR project is the study of decadal to centennial scale climate variability.

The objectives of the present Workshop were, 1. to bring together researchers active in decadal climate variability and continue the discussions begun in April 1996 in the JCESS-CLIVAR Workshop and in the various CLIVAR meetings that have taken place since then; 2. to provide inputs to NASA's Earth Science Enterprise from the decadal climate variability research community; and 3. to continue to develop an integrated framework of research in the description, physics, prediction, and societal applications of decadal climate variability; and its interaction with seasonal-to-interannual and anthropogenic climate phenomena.

There were approximately 50 participants in this Workshop, 38 of whom made oral presentations on various aspects of decadal climate variability and its societal impacts. In addition to the oral presentations, there were six sessions in which various aspects of decadal climate variability were discussed. The participants included programme managers from NASA and NOAA. Dr. Andreas Villwock represented the International CLIVAR project. A Report of the Workshop containing summaries of presentations and discussions, Workshop conclusions, Workshop recommendations, and extended abstracts of presentations is being prepared and will be available before the end of this year. A summary of the major conclusions and recommendations is presented here.

Workshop conclusions

1. The relative shortness and uneven quality of the instrument-measured climate record hampers our ability to quantify characteristics of global climate variability at decadal and longer time scales.
2. Nevertheless, analyses of this instrument-measured climate record has shown that there are global-scale, decadal and interdecadal variations in SST, rainfall over continents, SLP, upper-ocean heat content, near-surface winds over oceans, and surface temperatures over the U.S. The SST and upper-ocean heat content anomalies appear to rotate in the oceanic gyre circulations in observations and in the NCAR-DOE global coupled ocean-atmosphere model. The interdecadal SST variations appear to modulate tropical cyclone activity in the Pacific region.
3. There are also regional-scale patterns of SST, SLP, rainfall over continents, near-surface winds, and sea ice variations at decadal-multidecadal time scales in the Atlantic.
4. The ENSO phenomenon, its predictability, and its influence on the North American, Australian, and Asian climates exhibit strong, decadal-multidecadal variations. The strength of the ENSO-droughts connection in eastern U.S., southern California, and the Mississippi River valley has fluctuated at multidecadal time scales during the 20th century. Observations suggest that the above-mentioned decadal climate anomalies in the tropical-subtropical Pacific may be responsible for modulations of ENSO.
5. The following ‘targets’ appear promising for further investigations.
   (i) Decadal variability of ENSO, its predictability, and its teleconnections
   (ii) Decadal variability of the Asian-Australian monsoons and the ENSO-monsoon relationship
   (iii) Decadal variations in the North Pacific and North Atlantic climate systems, and the associated global rainfall anomalies
   (iv) A decadally-varying, meridional teleconnection pattern involving the tropical South Atlantic SSTs, SLP variations over the North Atlantic, deep convection in the Labrador Sea, sea ice and heat flux perturbations in the Greenland-Iceland-Norwegian Seas, and possibly the cross-equatorial SST gradient in the tropical Atlantic.
6. Further investigations with instrument-measured and paleoclimate data sets, and a variety of analysis techniques are necessary to further clarify characteristics of these ‘targets’, other global- and regional-scale decadal climate variations, and the relationship(s) between them.
7. Recent observational and modelling work has not shown evidence of coupled ocean-atmosphere modes of decadal variability in the extratropics. The model results suggest that integration of atmospheric forcings by the ocean may be the primary mechanism of decadal SST variability in the extratropics.
8. Coupled ocean-atmosphere GCMs and ocean-only GCMs generate variations in the North Atlantic

thermohaline circulation at 50-70 years time scale; observations suggest that phase-locking between these internally-generated climate variations and multidecadal solar irradiance variations may be responsible for the observed multidecadal climate variations.

9. A GISS GCM experiment suggests that the Earth's climate may be sensitive to 0.1%-0.25% variations in solar irradiance at multidecadal time scales. Approximately half the globally-averaged surface temperature increase during the last 100 years may be attributable to solar irradiance increases.
10. A preliminary assessment indicates that there is low predictability of decadal climate anomalies in dynamical, coupled ocean-atmosphere models; however, a statistical predictability study shows high-skill, multiyear-lead time predictability of decadal SST variations in the tropical Atlantic.
11. Analyses of satellite data products based on infra-red and microwave sounder radiance profiles show that inter-satellite calibration and analysis are required to get meaningful results on long-term climate variability. However, inherent uncertainties in using operational satellites due to orbit drift, instrument degradation, and inadequate sampling remain major problems.
12. Assimilation of satellite altimetric sea level observations by ocean general circulation models has demonstrated the utility of sea level data in estimating subsurface thermal and velocity fields. Data assimilation is a powerful tool for synthesizing various satellite observations in providing long-term global ocean analysis for climate research.

Workshop recommendations

1. A strategy to provide decade(s)-long, space-based, geophysical data products should be developed by space agencies. This encompasses the need to work carefully to maintain calibration and validation for long periods despite changes in technology, agency responsibility, and evolving science requirements. Long, global, well-maintained instrumental time series are critical to climate studies.
2. It is important to maintain high-quality measurements of sea surface height and extend the time series of global ocean winds. These are important quantities in decadal climate variability and in decadal variability of ENSO. A programme to demonstrate the feasibility of making high-accuracy, global measurements of sea surface salinity and precipitation from space-based platforms is needed as well. Solar irradiance variations must be tracked and compared with climate records.
3. In support of this space-based observing programme, there should be an in-situ measurement/ calibration programme using buoy- and float-mounted instruments. In view of the observations and model results showing a likely association between the subtropical gyres, and decadal SST and upper-ocean heat content anomalies, extensions of the TAO and PIRATA arrays to the equatorward sides of the subtropical gyres is worth considering. To observe gyre circulations and potential subduction processes, globally-deployed PALACE floats in the Atlantic and the Pacific are required that would reside along a particular subsurface density surface and profile to the surface intermittently. The assimilation of these space-based and in-situ observations in global ocean-atmosphere models should be an integral part of this programme.
4. More effort is needed to develop and rigorously analyse global ocean-atmosphere models to understand mechanisms of decadal climate variability; its predictability; and its interaction with ENSO, its predictability, and its global teleconnections.
5. U.S. scientists and their international collaborators need increased support for development of global instrumental and proxy databases through funding of special projects, including data archaeology and rescue projects. A hierarchy of quality-controlled ocean, atmosphere, and land data sets ranging from the basic data sets containing original measurements to various levels of derived data sets should be established; and the usefulness of each level of data should be assessed for various types of applications. The databases developed as a result of such projects will support efforts in climate system modelling and remote sensing.
6. There should be a programme to rigorously analyse these historical (instrument-measured and proxy) data sets to quantify characteristics of decadal climate variability, decadal variability of ENSO and its teleconnections, and to conduct empirical predictability studies.

The last two recommendations should be given a very high-priority. They are relatively inexpensive and will be the most useful in the near term.

Vikram Mehta with contributions from Tony Busalacchi, Tom Delworth, Clara Deser, Lee-Lueng Fu, Jim Hansen, Bill Lau, Syd Levitus, Eric Lindstrom, Gary Mitchum, Joel Susskind, and Warren White

VAMOS/SAMS Workshop - Executive Summary -

22-24 October 1998, Miami, Florida, USA

The first meeting of the VAMOS Working Group on the South American Monsoon System (SAMS) took place at NOAA/AOML (Atlantic Oceanographic and Meteorological Laboratory), Miami. The workshop was convoked to promote interaction and coordinate efforts of scientists interested in advancing the understanding and predictability of summer precipitation over South America.

The goals of the meeting were:

1. to assess the current state of knowledge on the South American Monsoon,
2. to identify gaps in this knowledge and field experiments (existing or already planned) designed to close these gaps,
3. to prioritize problems and
4. define special observing needs and numerical experiments as required for specific topics.

The workshop report is intended to further develop the science and implementation planning for VAMOS that was initiated with the CONAM meeting in Mexico City in 1997 and the VAMOS workshop earlier this year in São Paulo. A special session on the South American Monsoon Systems will take place during the 6th International Conference on Southern Hemisphere Meteorology and Oceanography, to be held April 3-7, 2000, in Santiago, Chile, to expose the science plans to a broad audience of interested scientists, further develop implementation planning, and entrain greater participation in the programme.

The meeting was attended by E. H. Berbery (U. Maryland), M. Douglas (NOAA/NSSL), D. Enfield (NOAA/AOML), R. Garreaud (JISAO and U. Chile), A. Grimm (U. Paraná, Brazil), C. Jones (UCSB), V. E. Kousky (NOAA/NCEP), R. Lawford (NOAA/OGP), B. Liebmann (CDC, U. Colorado), R. Mechoso (UCLA), G. Miranda (Institute of Ecology, Bolivia), K. Mo (NOAA/NCEP), M. Nicolini (U. Buenos Aires, Argentina), J. N-Paegle (U. Utah), M. Patterson (NOAA/OGP), G. Podesta (RSMAS), P. Silva-Dias (U. São Paulo, Brazil) and C. Vera (U. Buenos Aires, Argentina).

Participants demonstrated a keen interest in advancing knowledge on the SAMS through a programme of complementary activities on empirical studies, enhanced observational systems and development of numerical models that address the unique challenges presented by the South American steep orography and variable surface conditions.

The workshop discussed components, evolution and variability of SAMS, the relative importance of the Altiplano and Amazon heat sources, atmospheric teleconnections between the Americas during austral summer, numerical modelling applications for the region and ocean-atmospheric interactions. Current plans for a two-months field-experiment of the low-level jet east of the Andes was extensively discussed as well as a proposal for an expanded observational network for five years to improve monitoring of climate variability over the region. The discussion was lively and indicative of the support and interest that this research topic currently generates in several South-American countries and the USA. The role of international initiatives such as those of CLIVAR through VAMOS, the IAI and national funding institutions was also addressed. There was a general consensus in the readiness of the region to embark and support collaborative research on SAMS.

Such readiness is partly due to the enhanced regional awareness on the impact that summer precipitation and its variations have on water resource management, energy production, agriculture and health. In addition, links between summer precipitation over South America and inter-annual to intraseasonal processes such as El Niño-Southern Oscillation (ENSO), Atlantic sea surface temperatures and the Madden-Julian Oscillation are indicative of the inherent predictability of this precipitation regime. Improving the knowledge on these physical processes is a pre-requisite to substantial gains in the prediction of summer rains.

To better understand the dynamics of these links it is necessary to more completely quantify these relationships in the historical record. This quantification should be multidisciplinary and involve assessments of related variability in water resources, agricultural yields, tropical diseases and availability of energy. The impact of rainfall and temperature variability on human activities needs to be determined to assess vulnerability and to develop prediction techniques for better resource management.

The discussion isolated the following questions that limit our understanding of the SAMS:

- dynamical processes responsible for the onset, demise and character of the monsoon over different regions of South America.
- cause-effect relationships for monsoon modulations in scales from intraseasonal to interdecadal, including teleconnection patterns that span the Pan-American region.
- variability of the atmospheric and terrestrial components of the water and energy cycles at various

time scales, including the role of low-level flow in the vicinity of the Andes
- physical processes that cause the organization of nocturnal meso-scale convective systems in the La Plata river basin, and whether these are linked to low-level jets similar to those found over the North American plains.
- effect of the ITCZ and Atlantic SSTs in the modulation of the SAMS
- land-surface effects in various time scales.

The workshop discussion identified inadequate observations (both in quality and coverage) as well as limited availability of historical data over South America as the current most limiting factors to adequately address these questions. This situation will be partly alleviated in the future with the LBA experiment over Amazonia, availability of TRMM measurements and other products obtained by remote platforms. The workshop discussion identify as main priorities the recovery of precipitation and surface temperature data which in some countries go back to the beginning of the 20th century and endorsement of currently planned activities to enhance climate monitoring and deploy a field experiment on the low-level jet east of the Andes.

Julia N.-Paegle, U. Utah

Conference Announcements

4th International Conference on Modelling of Global Climate Change and Variability

13-17 September 1999

Max-Planck-Institut für Meteorologie, Hamburg

Four years after the “Third International Conference on Modelling of Global Climate Change and Variability”, we are pleased to invite the scientific community involved in climate research to meet in Hamburg once again. The conference will provide an opportunity to present new research results in this field and to discuss recent developments and plans for the future.

The Programme Committee, chaired by Lennart Bengtsson, Lydia Dümenil, and Klaus Hasselmann invites contributions on any of the following subjects:

1. Development and Validation of Comprehensive Climate Models and Emerging Issues

- Atmosphere, Oceans and Sea-ice
- Atmospheric Chemistry (Aerosols, Sulphur Cycle, Ozone, etc.)
- Biosphere
- Bio-geochemical Cycles
- Modelling Paleo-climates

2. Modelling of the Seasonal to Interannual Climate Variability (CLIVAR GOALS)

- ENSO: Extending and Improving Predictions (G1)
- Variability of the Asian-Australian Monsoon System (G2)
- Variability of the American Monsoon Systems (G3)
- African Climate Variability (G4)

3. Modelling Decadal to Centennial Climate Variability (CLIVAR DecCen)

- North Atlantic Oscillation (D1)
- Tropical Atlantic Variability (D2)
- Atlantic Thermohaline Circulation (D3)
- Pacific and Indian Ocean Decadal Variability (D4)
- Southern Ocean Climate Variability(D5)

4. Prediction, Detection and Attribution of Anthropogenic Climate Change (CLIVAR ACC)

- Climate Change Prediction (A1)
- Climate Change Detection and Attribution (A2)
- Integrated Assessments
- Prediction of Extremes

Each subject will be introduced by an invited review lecture. Abstracts for reviewing (1 page containing authors’ names, affiliation, address, e-mail address and telephone/facsimile numbers) should be received in duplicate by 1 March 1999 at the address listed below.

In order to receive further circulars for this conference, please notify us before 31 January 1999.

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IUGG99
18 - 30 July 1999
University of Birmingham, UK

On the 22nd General Assembly of the International Union of Geodesy and Geophysics (IUGG 99) at the University of Birmingham, UK, 18th to 30th July 1999 there will be number of CLIVAR related sessions. Enclosed please find a selection of the most relevant ones. In addition, please check out the IUGG99 website at:

http://www.bham.ac.uk/IUGG99/

Note that the deadline for submission of abstracts is **15 January 1999 !!**

Global Change and Predictability (U2)

Convenor: Chris Rapley, Director, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK, tel.: +44(0)1223-251524; fax: +44(0)1223-350456, Email: c.rapley@bas.ac.uk

Data Assimilation in Meteorology and Oceanography (JSP05)
Convenors:
Paola Malanotte-Rizzoli, Massachusetts Institute of Technology, l4l6 Department of Earth, Atmospheric and Planetary Sciences, Cambridge, MA 02139, USA, FAX: (617) 253- 4464; Email: rizzoli@ocean.mit.edu
Philippe Courtier, Laboratoire d'Oceanographie Dynamique et de Climatologie, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cedex, France, Tel.: +33 1 44 27 70 73; fax: +33 1 44 27 38 05; Email: courtier@lodyc.jussieu.fr

Ocean/Atmosphere variability and predictability (JSP25)
The symposium will be divided into three parts:
a) ENSO variability
b) Seasonal-Decadal variability
c) Decadal-Centennial variability
Convenors:
a) Michael Davey, Hadley Centre, Meteorological Office, London Road, Bracknell, RG12 2SY, UK, Tel.: +44 (0) 1344 854 648, Email: mkdavey@meto.gov.uk
b) David Stephenson, Meteo-France, 42 av Coriolis, 31057 Toulouse, Cedex, France, Tel.: +33 (0) 5 61 07 96 98; Fax: +33 (0) 5 61 07 96 10, Email: David.Stephenson@meteo.fr
c) Shoshiro Minobe, Division of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, N-10, W-8, 060-0810, Sapporo, Japan, Tel.: +81 (0) 11 706 2644; Fax: +81 (0) 11 706 4907, Email: minobe@neptune.sci.hokudai.ac.jp

Non-linear Dynamics and Climate Prediction (MI11)
Convenor: Han-Ru Cho, Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7, tel.: +1-416-978-4992. fax: +1-416-978-8905; Email: cho@physics.utoronto.ca

Improvements and intercomparisons of climate system models and their component models (MC01)
Convenor: Peter Gleckler, Program for Climate Models Diagnosis and Intercomparison, Lawrence Livermore National Laboratory, Box 808, Livermore, CA, 94550, USA, phone: +1 925- 422- 7631, fax: +1 925 422 7675, Email: gleckler@pcmdi.llnl.gov

Detection and attribution of climate change (MC02)
Convenor: Phil Jones, Climate Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK; Phone: +44 (0) 1603-592-090; fax: +44 (0) 1603 507784; Email: p.jones@uea.ac.uk

Sudden climate change (MC03)
Convenor: Jean Jouzel, Laboratoire des Sciences du Climat et de l'Environnement, UMR CEA-CNRS 1572, CEA Saclay, Orme des Merisiers, 91191 Gif/ Yvette France; Phone +33 1 69087713; fax: +33 1 69087716; Email: jouzel@lmce.saclay.cea.fr

Radiative forcing and climate change (MC07)
Convenor: Keith Shine, University of Reading, Department of Meteorology, Earley Gate, PO Box 243, Reading RG6 6BB, UK; Phone: +44-1189-318405; fax: +44-1189-318905; Email: k.p.shine@reading.ac.uk

On the Use of Coupled Models for Paleoclimate Studies (MC11)
Convenor: Nathalie de Noblet, Laboratoire des Sciences du Climat et de l'Environnement; Laboratoire mixte de recherche CEA- CNRS; Orme des Merisiers / Bat. 709; 91191 Gif-sur- Yvette cedex, France. tel. +33-1-69.08.77.26; fax. +33-1 69.08.77.16; Email: noblet@lsce.saclay.cea.fr

CLIVAR Calendar

1998	Meeting	Location	Attendance
December 2 - 4	International CLIVAR Conference	Paris, France	Limited
December 6 - 10	AGU Fall Meeting	San Francisco, USA	Open
1999	**Meeting**	**Location**	**Attendance**
January 10 - 15	79th AMS Annual Meeting	Dallas, USA	Open
March 15 -19	Joint Scientific Committee of WCRP, 20th Session	Kiel, Germany	Invitation
March 16 - 19	VAMOS Panel, 2nd Session	Buenos Aires, Argentina	Invitation
April 14 - 16	WOCE/CLIVAR Data Products Committee - 12th Session	Birkenhead, UK	Invitation
April 19 - 23	24th General Assembly European Geophysical Society	Den Haag, The Netherlands	Open
May 5 - 8	10th Conference on Global Warming	Fujiyoshida, Yamanashi, Japan	Open
May 31 - June 4	AGU Spring Meeting	Boston, USA	Open
June 16 - 19	3rd International Scientific Conference on the Global Energy and Water Cycle	Beijing, P.R. China	Open
July 19 - 30	IUGG/IAPSO	Birmingham, UK	Open
August 23 - 27	WOCE North Atlantic Workshop	Kiel, Germany	Limited
September 13 - 17	4th Conference on Modelling of Global Climate Change and Variability	Hamburg, Germany	Open

For more information, please contact the ICPO or check out our web-page: **http://www.dkrz.de/clivar/latest.html**

Please return to the International CLIVAR Project Office by mail or email (**icpo@soc.soton.ac.uk**)

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